DOCUMENT RESUME

ED 220 520 TM 820 538

AUTHOR Darom, Efraim
TITLE Discriminant Validity Investigation by Facet Analytic Approach.
PUB DATE [Mar 82]
NOTE 22p.

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Discriminant Analysis; Evaluation Methods; *Factor Structure; Mathematical Models; Path Analysis; Research Methodology; *Statistical Analysis; *Validity
IDENTIFIERS *Facet Analysis; *Multitrait Multimethod Techniques; Theory Development

ABSTRACT

In an analysis of multitrait-multimethod matrices the criteria for discriminant validity are shown to include a "structure" criterion as an invariance of traits structure to methods. The criterion is meant to fit data to an additive model with traits and methods but not interaction terms. The importance of the structure criterion and the relative unimportance of the two elevation criteria are shown. A fourth criterion which is also a "structure" hypothesis is discusses as a "heterotrait-heteromethod" block. Applying the facet approach to the analysis of multitrait-multimethod matrices is a step forward in validity investigations since it ties together Campbell and Fiske's criterion which is "theory free" with Cronbach's ideas about construct validity. The pictorial nature of space diagrams helps researchers see many aspects of data usually unnoticed in other approaches. (Author/CM)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED220520

BAR-ILAN UNIVERSITY אוניברסיטת בר-אילן
RAMAT-GAN, ISRAEL TEL 718111 .טל רמת-גן

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

Discriminant Validity Investigation by Facet Analytic Approach

Efraim Darom

Bar Ilan University

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
E. Darom
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Introduction

The analysis of Multitrait-Multimethod (MTMM) matrices recieved much attention following the classic paper by Campbell and Fiske (1959). In that work three criteria were suggested for discriminant validity. 1) Correlations between different methods measuring the same trait (validity diagonal, marked "a") should be higher than correlations between different methods measuring different traits (marked "c"). 2) Correlations in the validity diagonal should be higher than correlations between diferent traits measured by the same method (marked "b"); and 3) The same pattern of correlations between traits should emerge in different methods (the pattern of correlations marked "b1" should be the same as in "b2".

---

insert table 1 here

Most research on MTMM matrices, which includes approaches such as Factor Analysis ,Analysis of Variance and path analysis have been concentrated on the first two criteria which could be regarded as "elevation" criteria, and less attention has been given to the third criterion which is a "structure" criterion. An excellent review of these approaches is Schmitt et al. (1977)

The structure criterion is an invariance of traits structure to methods. This resembles the invariance of an effect to levels of a second factor in

TM 820538

PRINTED BY IBM 370/168 .O.S.י מודפס ע"י מחשב

an experimental design where no interaction exists between the two factors. Hence, the third criterion could be regarded as an attempt to fit data to to an additive model which includes traits and methods but not interaction terms

The purpose of this work is to show the importance of the structure criterion and the relative unimportance of the elevation criteria. Satisfaction of the elevation criteria is highly dependent on the particular choice of methods. For a given degree of relationship between traits, if a researcher selects similar methods he will capitalize on this similarity and will satisfy the second criterion. If, on the other hand, he happened to select methods which are dissimilar he will have a large "method variance" and a phenomenon known as "halo effect" will be observed. This applies for situations in which traits are "fixed" in the sense that they represent the whole population of traits in which the researcher happens to be interested, while the methods are "random" in the sense that they represent a random sample of methods in which the researcher might want to measure the traits. This is usually the case for discriminant validity investigations. When methods are also "fixed", then the elevation criteria are as important as the structure criterion.

The recognition of "no trait-method interaction" as a necessary and (sometimes) sufficient condition for discriminant validity suggests a fourth criterion which is also a "structure" hypothesis. This regards the structure of elements in the "heterotrait-heteromethod" block (those marked "c"). The pattern of these elements should be similar to that of the "b" elements. i.e., the same hierarchy of correlations within each column of "b1" should maintain itself at the equivalent column of "c", and also a

PRINTED BY I.B.M. 370/168 הודפס ע"י המחשב ו.ב.מ.

similar hierarchy of correlations within each row of "b2" should maintain itself at the equivalent row of "c". Campbell and Fiske did not consider this criterion as part of their definition for discriminant validity. It is the purpose of this work to show its relevance for discriminant validity from the perspective of the "no trait-method interaction" underlying condition.

Traits and Methods as Facets

The theoretical framework, as well as the empirical tools of this work stem from Guttman's approach to theory building. According to Guttman's definition a theory is an "hypothesis of a correspondence between a definitional system for a universe of observations and an empirical aspect of that universe together with a rationale for such an hypothesis" (in Gratch,1973).Cronbach considered this definition as one which includes the concept of Construct Validity (Guttman,in press)

Facet design provides the definitional system of the observations together with the rationale for hypotheses.The empirical aspect of the theories usually dealt with,is the set of intercorrelations amongst the observations. A mapping sentence is a useful tool in providing a content design which specifies both similarities and dissimilarities between observations.Excellent discussions of facet design can be found in Shye(1978) and Levy(1981).

Since observations in a MTMM situation could be classified with respect to both trait and method,the following general mapping sentence could be used to represent the overall design:

PRINTED BY I.B.M. המדפס ע"י המחשב ת.ד. 370/168

		T		M		R
		|t1|		|m1|	|high|
The assesment of individual (x) in trait		|t2|	by method	|m2|	---> | to |
		|. |		| .|	|low |
		|ti|		|mj|	| |

assesment with regard to facet T.

Traits must have common range (e.g. attitudes) for the mapping sentence to be logical, hence some relationship between traits must exist. The correspondence between the definition of the MTMM design as expressed by the mapping sentence and the actual correlation matrix might be explored or confirmed depending on whether the researcher has apriori hypotheses regarding the nature of relationship between facets' elements .

If traits could be regarded as elements of a single ordinal variable a simplex pattern hypothesis could be stated.The traits'facet is hypothesized then to play an axial role which geometrically means division of the space to layers. A circular pattern termed circumplex could be hypothesized in other situations. The facet then plays a polar role and geometrically divides the space to wedge-like parts. Figure 1 illustrates these two roles:

---

insert figure 1 here

Hypotheses then could be made regarding the nature of order which exists between facets' elements and regarding the relationship of two facets to each other. The researcher need not specify the nature of order in discriminant validity investigations. The structure criteria discussed in

PRINTED BY I.B.M 370/168 הודפס ע"י המחשב ר.ב.מ.

the introduction suggests the invariance of traits' facet role to elements of the methods' facet only.

The correspondence between the correlation matrix and the structure suggested by the mapping sentence is usually analyzed by Smallest Space Analysis (Guttman,1968; Lingoes,1973). Smallest Space Analysis (SSA) treats each variable as a point in a euclidean space in such a way that the higher the correlation between two variables the closer they are represented in the space. The fit between the original correlations and the distances in the space is indicated by the coefficient of alienation. The smaller that coefficient the better the fit. The following example demonstrates how a discriminant validity investigation can be done with the framework of facets and by the SSA technique. Levin (1973) analyzed data collected in small group interaction experiments. The four traits and three methods used are given in the following mapping sentence:

		A			
		prominence			
		achievement			
The extent of		affiliation	shown by individual (x) as judged		
		leadership			
	B			R	
	himself			very high	
by	peers	--->		to	
	observer			very low	

The 12x12 intercorrelation matrix reported in table 2 is based on 240 subjects

Levin's data was analyzed by SSA. The space diagram given in figure 2 is a two dimensional projection of a three dimensional solution with a 0.07 coefficient of alienation. The traits' facet plays a modulating role while the methods' facet plays a polar role. The diagram clearly reveals the invariance of traits'structure across methods, hence a good discriminant validity. The space diagram points out another aspect of Levin's data which

PRINTED BY I.B.M. 370/168 .מ.ב.ג המדפס עי"מחשב

would have been gone d unnoticed with other approaches to the analysis of MTMM matrices. It is clear that the four traits form a simplex and the same simplex exists within each method. The order aspect of prominence, leader, achievement and affiliation,which is also reflected in the three monomethod matrices, could serve as a trigger for theory development. Questions could be asked regarding the reason for that particular order and predictions could be made regarding the location of other related traits.

---

insert table 2 and figure 2 here

Method

If one considers the four criteria reviewed as dichotomous, one has sixteen possible types of matrices which differ by number as well as by type of satisfied criteria. I used only the eight types marked in Table 3, since the third criterion is considered necessary by both Campbell and Fiske and myself.

---

insert Table 3 here

The matrices used in this study are 8x8 matrices which describe (hypothetical) relationship among four traits T1,T2,T3,T4 which are measured by two methods M1,M2. The A1B1C1D1 matrix was constructed in the following way:

1. Validity diagonal elements were set to .75

PRINTED BY I.B.M. 370/168 הודפס ע"י מחשב

2. Intertrait correlation submatrices were set to follow the (same) simplex pattern with a slight difference in elevation, and in total elevation less than .75. This simultaneously satisfies the second and the third criteria.

3. Heterotrait-Heteromethod elements were also set to have the (same) simplex pattern as the b's with an elevation lower than .75. This simultaneously satisfies the first and fourth criteria.

The other matices were constructed by systematically changing either elevations (for A1B2C1D1, A2B1C1D1, and A2B2C1D1) or pattern (for A1B1C1D2 matrix) or both (for A1B2C1D2, A2B1C1D2 and A2B2C1D2).

Each matrix was analyzed by the SSA. Since the intertrait pattern used in this work is a simplex a geometrical representation which places the four traits T1, T2, T3, T4 in that order on a straight line (or a curve with an angle less than 180 degrees) is anticipated for both methods. It is predicted that only matrices satisfying the structure criteria (i.e. matrices AiBjC1D1) will lead to such geometrical representations, while those not satisfying them, (i.e. AiBjC1D2) will not.

Results

The eight matrices together with their space diagrams are presented in Tables 4 thru 11. The space diagram of table 4 shows that the initial simplex pattern prevails . The four traits are spread in a semi-circular form which is one of the typical geometrical representation of simplex patterns. The inner points represent the four traits measured by M1. Their distances from each other are smaller than those of the points in the outer semi-circle because of the higher elevation of "b1" as compared with "b2".

PRINTED BY I.B.M. 370/168 הודפס ע"י המחשב ר.ב.מ.

The low alienation indicates that the two-dimensional space diagram accurately represents the similarity between the variables in the original correlation matrix.

---

insert Tables 4 thru 11

The space diagram which represents the correlation matrix of table 5 maintains the two simplexes in spite of the fact that one element in the validity diagonal (a) is lower than off- diagonal elements (c). The moderate though acceptable alienation cannot disguise the finding that,in spite of the violation of the first criterion for discriminant validity, the use of two methods does not distort the true relationship among the four traits. The two space diagrams which represent the correlation matrices of Tables 6 and 7 add support to this finding. In spite of the fact that there was an "halo effect"in Table 6, which is a violation of the second criterion, and in spite of the fact that both the first and second criteria were violated in table 7, the corresponding space diagrams clearly show the two simplexes.

The situation is different for those matrices in which structure, or both structure and elevation were manipulated. The space diagram which represent Table 8 shows with a moderate alienation that a circumplex, or a complete circular order exists among the four traits. This is in complete disagreement with the simplex relationship which exists among the "b" elements. The fact that traits T1 and T4 are highly correlated when measured by different methods, while least correlated when measured by the same method, introduces a trait-method interaction which distorts the true

PRINTED BY I.B.M. 370/168 הודפס ע"י המחשב ו.ב.מ.

simplex relationship among the four traits. The matrix in Table 8 is perfect with regard to the first three criteria, and therefore has discriminant validity according to Campbell and Fiske. Still its geometrical representation gives the wrong information regarding the relationship among traits.

The remaining space diagrams representing the correlation matrices of tables 9,10,and 11 show how different structure between the "b" and "c" elements combined with violation of the elevation criteria give both a poor fit and a distorted picture of the relationship between traits

Conclusion

Using facet approach to the analysis of multitrait multimethod matrices is a step forward in validity investigations since it ties together Campbell and Fiske's criterion which is "theory free" with Cronbach's ideas about construct validity. The pictorial nature of space diagrams provided by the ssa program helps researchers see many aspects of data usually unnoticed by other approaches.

PRINTED BY I.B.M 370/168 ,מ.ב.ג התפס ע"י המחשב

BIBLIOGRAPHY

Campbell,D.T. and Fiske,D.W. Convergent and discriminant validity by the multitrait-multimethod matrix. Psychological Bulletin, 1959, 56,81-105

Darom,E. Facet analytic approach to the analysis of multitrait multimethod matrices. Unpublished manuscript, Bar-Ilan University, Israel

Gratch,H. (Ed.) 25 years of social research in israel. Jerusalem: Academic Press, 1973.

Guttman,L. A general nonmetric technique for finding thesmallest coordinate space for a configuration of points. Psychometrika, 1968, 33,496-506.

Guttman,L. what is not what in theory construction. in Hanser,R.N. Mechanic,D. and Heller,N.A. (Eds.) Social structure and personality (in press)

Levin,J. Bifactor analysis of a multitrait-multimethod matrix of leadership criteria in small groups. Journal of Social Psychology, 1973, 89,295-299.

Levy,S. Lawful roles of facets in social theories. In Borg,I (Ed.) Multidimensional data representation: When and why. Ann Arbor: Mathesis Press, 1973.

Lingoes,J.C. The Guttman-Lingoes Nonmetric Program Series. Ann-Anrbor: Mathesis Press, 1973.

Schmitt,N., Coyle,B.W., and Saari,B.B. A review and critique of analyses of multitrait multimethod matrices. Multivariate Behavioral Research, 1977, 12,447-478.

Shye,S. (Ed.) Theory construction and data analysis in the behavioral science. San-Francisco: Jossey-Bass, 1978.

PRINTED BY I.B.M. 370/168 .מ.ב.ג הודפס ע"י המחשב

BAR-ILAN UNIVERSITY אוניברסיטת בר-אילן
RAMAT-GAN, ISRAEL TEL 718111 טל. רמת-גן

TABLE 1
STRUCTURE OF A MULTITRAIT-MULTIMETHOD MATRIX

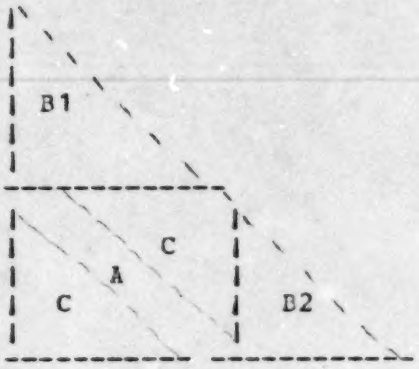
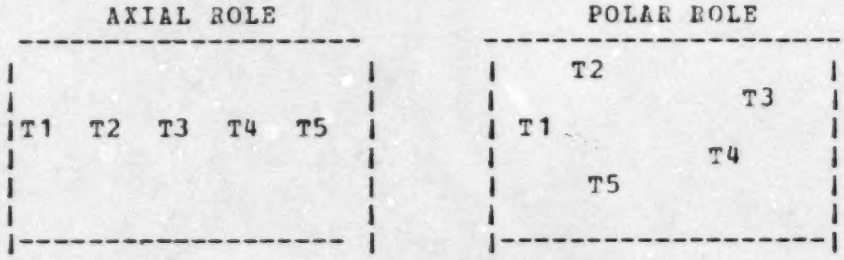


FIGURE 1
GEOMETRICAL PRESENTATION OF TWO ROLES OF
TRAIT FACET WITH FIVE TRAITS



PRINTED BY I.B.M. 370/168 המדפס עי"י המחשב ע"ש

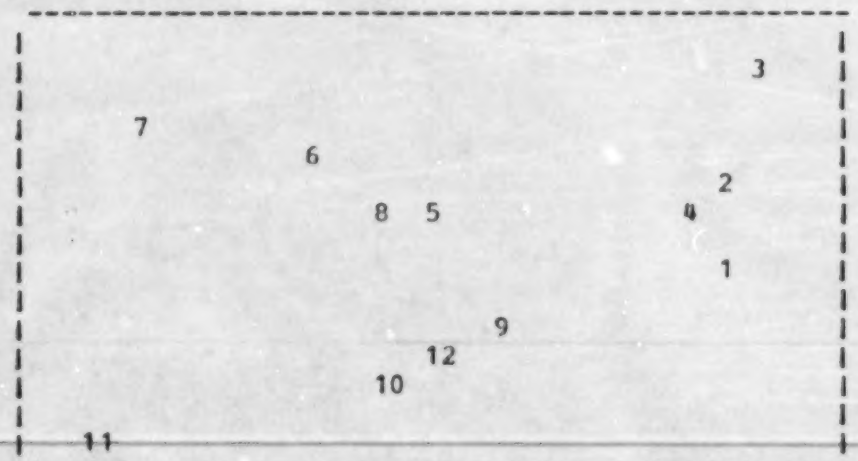
BAR-ILAN UNIVERSITY אוניברסיטת בר-אילן
RAMAT-GAN ISRAEL TEL 718111 טל. רמת-גן

TABLE 2

Multitrait multimethod matrix. Data from Levin(1973)

trait	method I a	b	c	d	method II a	b	c	d	method III a	b	c	d
I self rating												
1.prominence												
2.achievemnt	50											
3.affiliation	41	48										
4.leader	67	59	40									
II peer ratings												
5.prominence	45	33	26	55								
6.achievement	36	32	31	43	72							
7.affiliation	25	21	25	30	59	72						
8.leader	46	36	28	51	85	80	69					
IIIobserver ratings												
9.prominence	53	41	34	56	71	58	43	72				
10.achievement	50	45	29	52	59	55	42	63	84			
11.affiliation	36	20	28	37	53	51	43	57	62	57		
12.leader	52	43	31	59	68	60	46	73	92	89	63	

FIGURE 2
SPACE DIAGRAM OF LEVIN'S DATA



PRINTED BY IBM הודפס ע"י מחשב י.ב.מ. 370/145

TABLE 3
CHARECTERISTICS OF EIGHT MATRICES

	A	B	C	D
1. A1B1C1D1	+	+	+	+
2. A1B2C1D1	+	-	+	+
3. A2B1C1D1	-	+	+	+
4. A2B2C1D1	-	-	+	+
5. A1B1C1D2	+	+	+	-
6. A1B2C1D2	+	-	+	-
7. A2B1C1D2	-	+	+	-
8. A2B2C1D2	-	-	+	-

PRINTED BY IBM 370/148 הודפס ע"י מחשב I.B.M.

TABLE 4
SSA FOR MTMM ON A1B1C1D1 SIMPLEX DATA

	1	2	3	4	5	6	7	8
1.	0.0							
2.	0.60	0.0						
3.	0.50	0.65	0.0					
4.	0.40	0.45	0.55	0.0				
5.	0.75	0.50	0.40	0.30	0.0			
6.	0.50	0.75	0.55	0.35	0.55	0.0		
7.	0.40	0.55	0.75	0.45	0.45	0.60	0.0	
8.	0.30	0.35	0.45	0.75	0.35	0.40	0.50	0.0

COEFFICIENT OF ALIENATION = 0.684248E-01

SPACE DIAGRAM

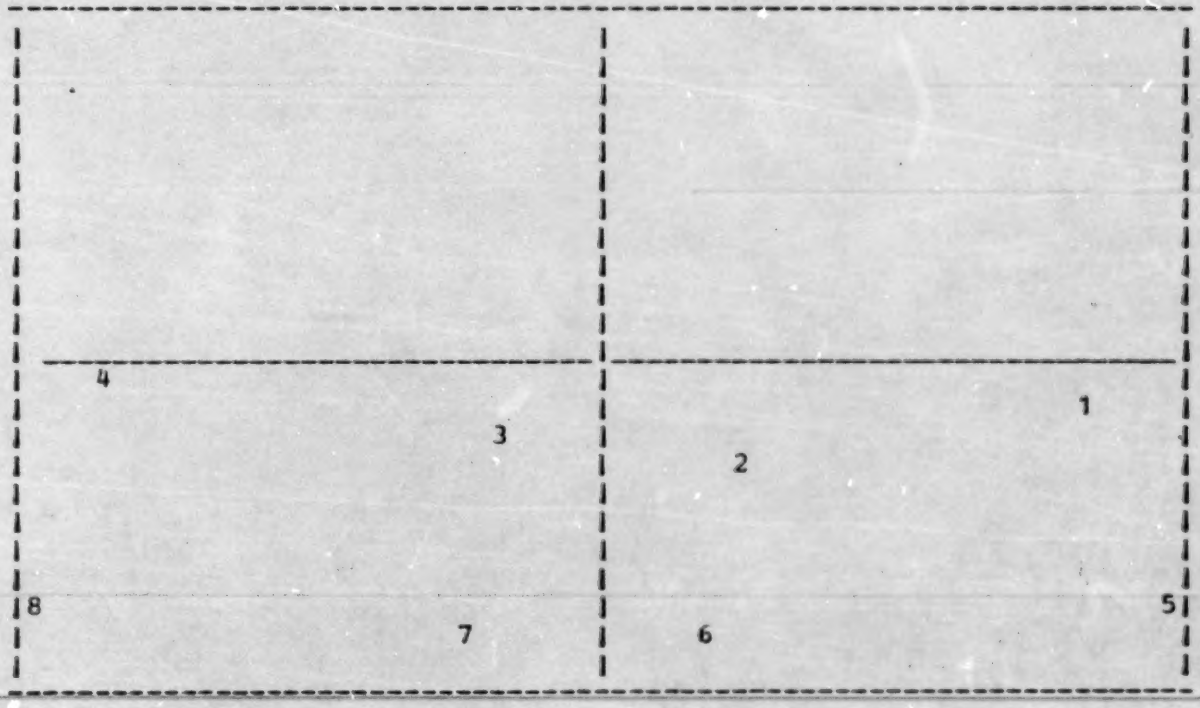
PRINTED BY IBM 370/168 הודפס ע"י המחשב ר.ב.מ.

TABLE 5
SSA FOR MTMM ON A2B1C1D1 SIMPLEX DATA

	1	2	3	4	5	6	7	8
1.	0.0							
2.	0.30	0.0						
3.	0.20	0.65	0.0					
4.	0.10	0.45	0.55	0.0				
5.	0.45	0.50	0.10	0.00	0.0			
6.	0.50	0.75	0.25	0.05	0.25	0.0		
7.	0.10	0.25	0.75	0.15	0.15	0.60	0.0	
8.	0.00	0.05	0.15	0.75	0.05	0.40	0.50	0.0

COEFFICIENT OF ALIENATION = 0.146606E+00

SPACE DIAGRAM



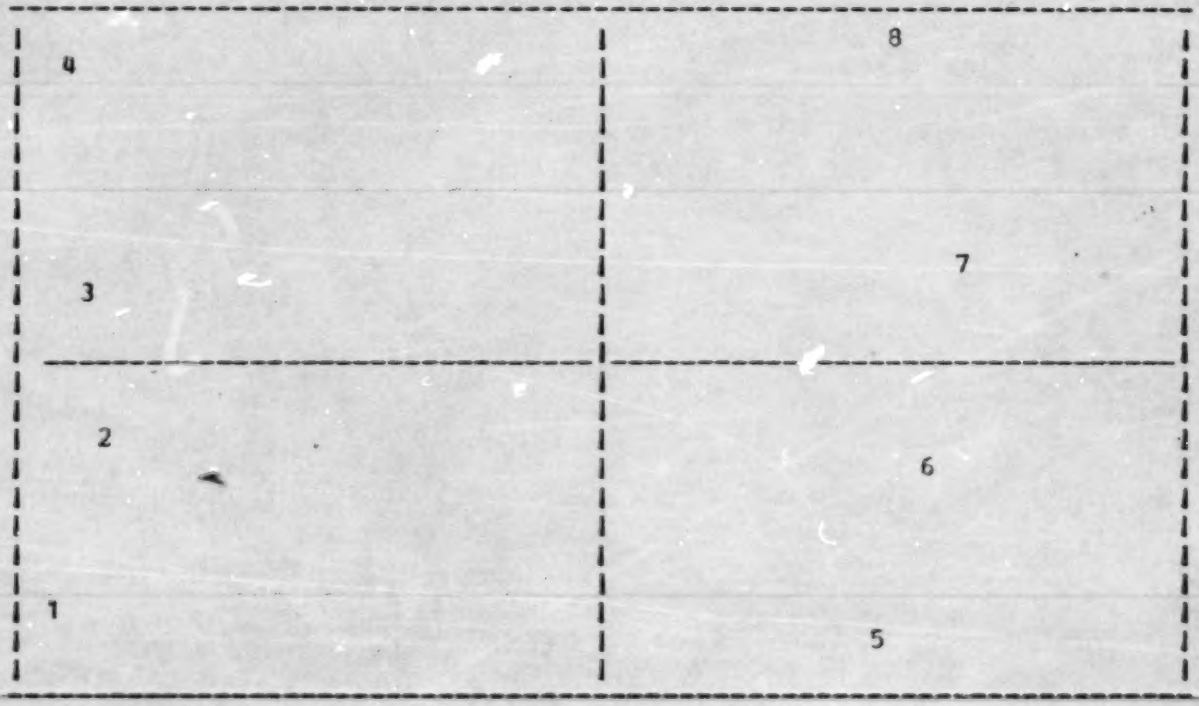
PRINTED BY IBM 370/168 .O.S הודפס ע"י מחשב

TABLE 6
SSA FOR MTMM ON A1B2C1D1 SIMPLEX DATA

	1	2	3	4	5	6	7	8
1.	0.0							
2.	0.60	0.0						
3.	0.50	0.65	0.0					
4.	0.40	0.45	0.55	0.0				
5.	0.75	0.20	0.10	0.00	0.0			
6.	0.50	0.45	0.25	0.05	0.55	0.0		
7.	0.10	0.25	0.45	0.15	0.45	0.60	0.0	
8.	0.00	0.05	0.15	0.45	0.35	0.40	0.50	0.0

COEFFICIENT OF ALIENATION = 0.583693E-01

SPACE DIAGRAM



PRINTED BY IBM 370/168 הודפס ע"י מחשב I.B.M.

TABLE 7
SSA FOR MTMM ON A2B2C1D1 SIMPLEX DATA

	1	2	3	4	5	6	7	8
1.	0.0							
2.	0.60	0.0						
3.	0.50	0.65	0.0					
4.	0.40	0.45	0.55	0.0				
5.	0.45	0.50	0.10	0.00	0.0			
6.	0.50	0.45	0.25	0.05	0.55	0.0		
7.	0.10	0.25	0.45	0.15	0.45	0.60	0.0	
8.	0.00	0.05	0.15	0.45	0.35	0.40	0.50	0.0

COEFFICIENT OF ALIENATION = 0.776564E-01

SPACE DIAGRAM

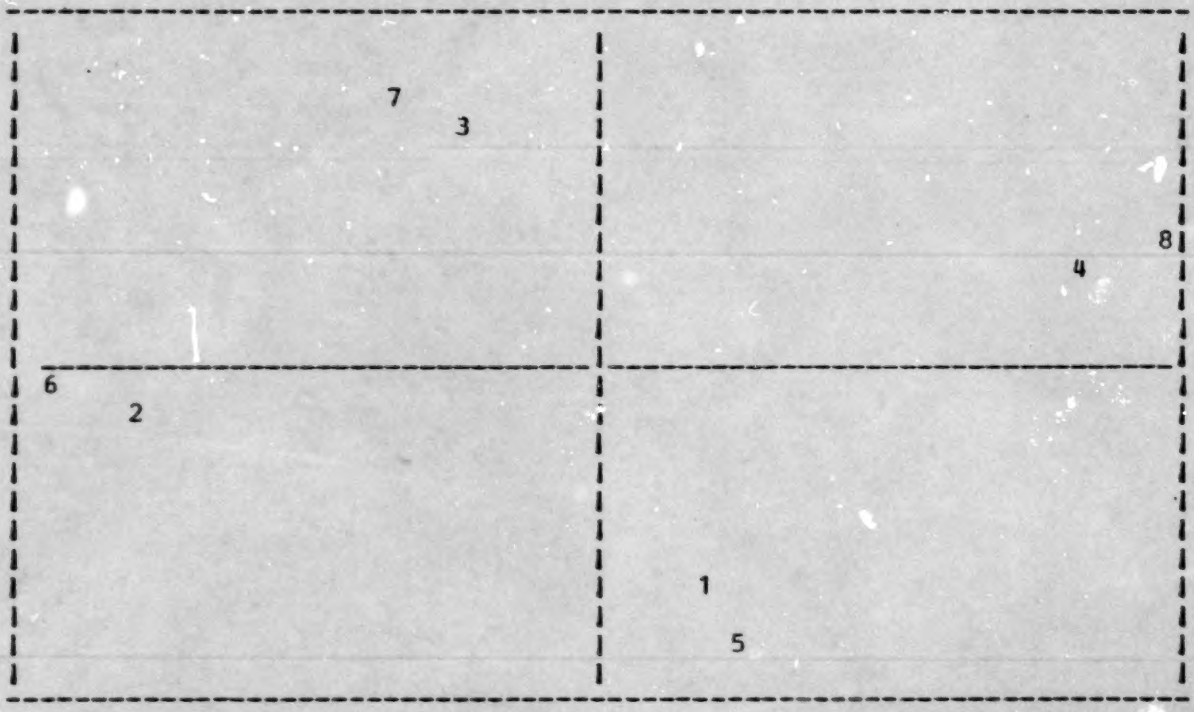
PRINTED BY IBM 370/168 מדפס ע"י

TABLE 8
SSA FOR MTMM ON A1B1C1D2 SIMPLEX DATA

	1	2	3	4	5	6	7	8
1.	0.0							
2.	0.60	0.0						
3.	0.50	0.65	0.0					
4.	0.40	0.45	0.55	0.0				
5.	0.75	0.30	0.40	0.50	0.0			
6.	0.30	0.75	0.55	0.35	0.55	0.0		
7.	0.40	0.55	0.75	0.45	0.45	0.60	0.0	
8.	0.50	0.35	0.45	0.75	0.35	0.40	0.50	0.0

COEFFICIENT OF ALIENATION = 0.151457E+00

SPACE DIAGRAM



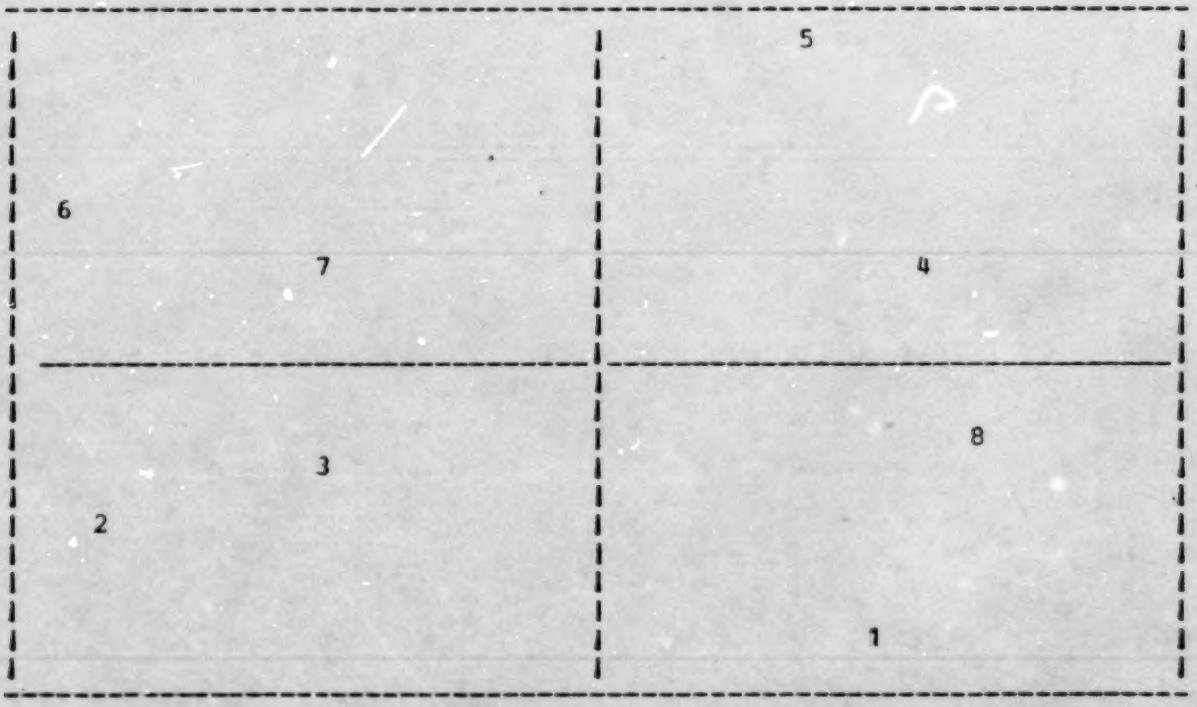
PRINTED BY IBM 370/168 .מ.ב.י הודפס ע"י מחשב

TABLE 9
SSA FOR MTMM ON A2B1C1D2 SIMPLEX DATA

	1	2	3	4	5	6	7	8
1.	0.0							
2.	0.30	0.0						
3.	0.20	0.65	0.0					
4.	0.10	0.45	0.55	0.0				
5.	0.45	0.00	0.10	0.50	0.0			
6.	0.00	0.75	0.25	0.05	0.25	0.0		
7.	0.10	0.25	0.75	0.15	0.15	0.60	0.0	
8.	0.50	0.05	0.15	0.75	0.05	0.40	0.50	0.0

COEFFICIENT OF ALIENATION = 0.258336E+00

SPACE DIAGRAM



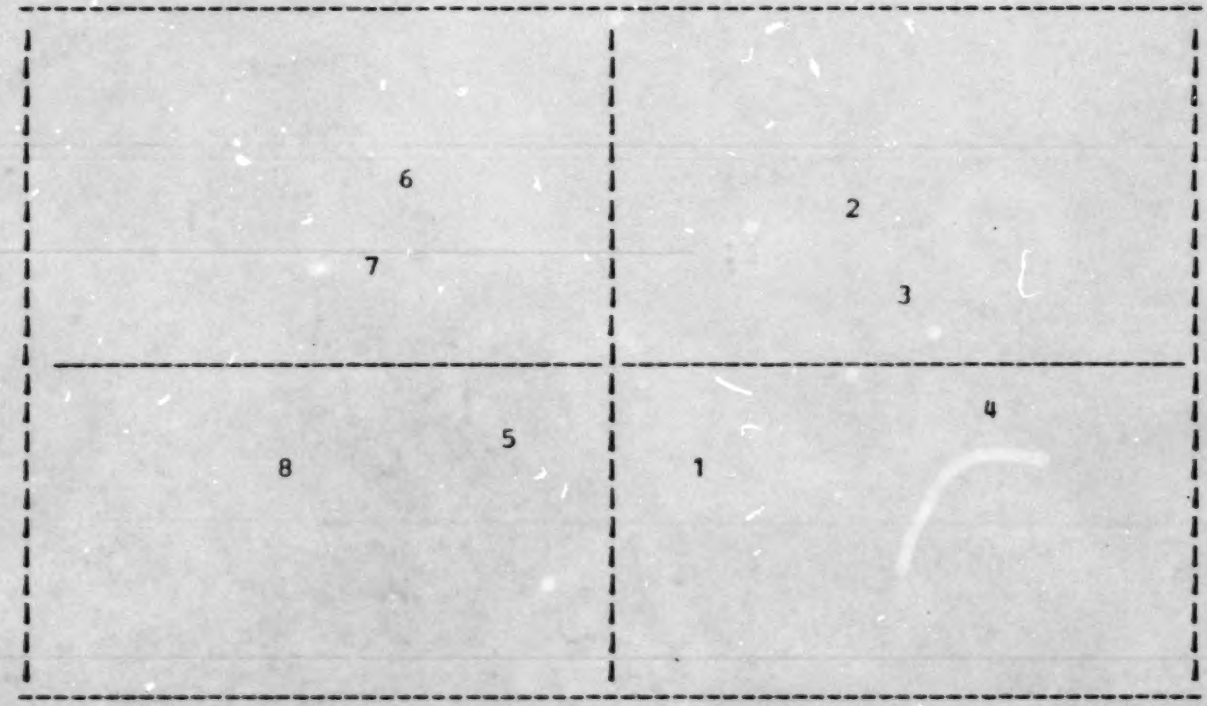
PRINTED BY IBM 370/168 .מ.ח.י הודפס ע"י

TABLE 10
SSA FOR MTMM ON A1B2C1D2 SIMPLEX DATA

	1	2	3	4	5	6	7	8
1.	0.0							
2.	0.60	0.0						
3.	0.50	0.65	0.0					
4.	0.40	0.45	0.55	0.0				
5.	0.75	0.00	0.10	0.50	0.0			
6.	0.00	0.45	0.25	0.05	0.55	0.0		
7.	0.10	0.25	0.45	0.15	0.45	0.60	0.0	
8.	0.50	0.05	0.15	0.45	0.35	0.40	0.50	0.0

COEFFICIENT OF ALIENATION = 0.245222E+00

SPACE DIAGRAM



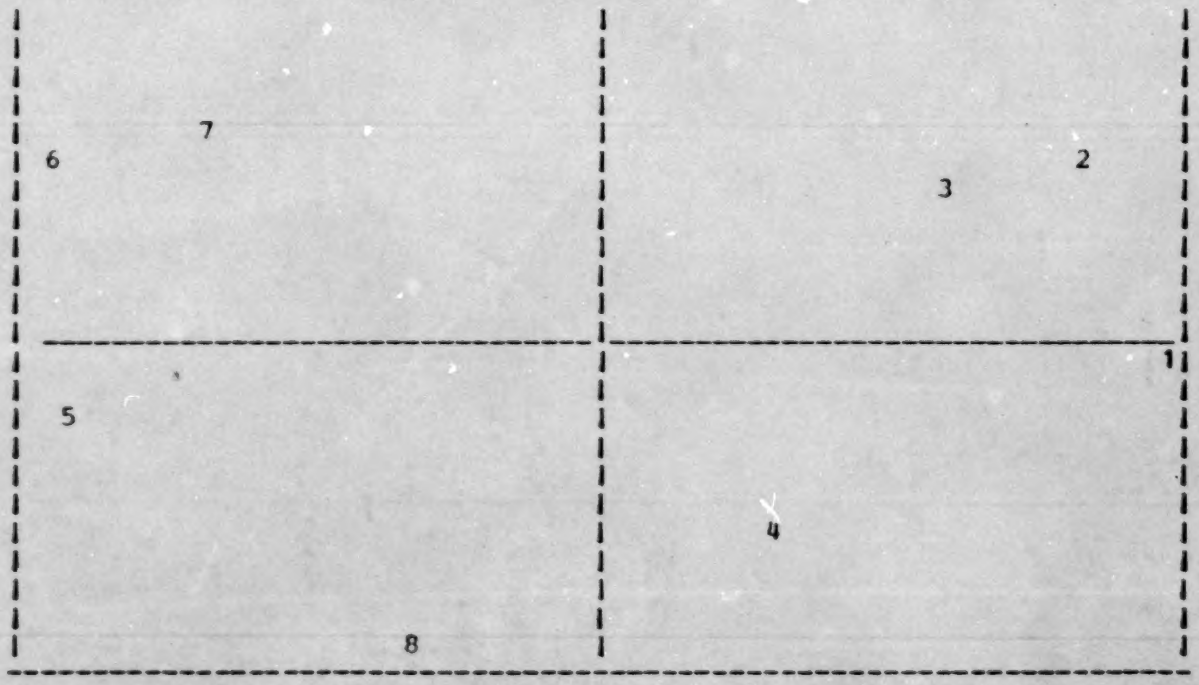
PRINTED BY IBM 370/168 ,מדפס ע"י המחשב ,ב.א.

TABLE 11
SSA FOR MTMM ON A2B2C1D2 SIMPLEX DATA

	1	2	3	4	5	6	7	8
1.	0.0							
2.	0.60	0.0						
3.	0.50	0.65	0.0					
4.	0.40	0.45	0.55	0.0				
5.	0.45	0.00	0.10	0.50	0.0			
6.	0.00	0.45	0.25	0.05	0.55	0.0		
7.	0.10	0.25	0.45	0.15	0.45	0.60	0.0	
8.	0.50	0.05	0.15	0.45	0.35	0.40	0.50	0.0

COEFFICIENT OF ALIENATION = 0.232592E+00

SPACE DIAGRAM



PRINTED BY IBM 370/168 .מ.ג.י הודפס ע"י